Hypermedia Patient Data Retrieval and Presentation Through WWW

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WWW can be a helpful tool for PACS and HIS data retrieval and presentation. The use of gateways to access both text and hypermedia databases (images and video) enables fetched data to be presented in virtually any computer system. WWW browsers provide a very friendly interface and require little training to operate. This paper presents a prototype that uses a SQL gateway for accessing relational patient databases. The dataset used here include text data from reports of diagnostic procedures as well as pointers to the corresponding images. Images can be displayed by the browsers' viewers.

INTRODUCTION

The pursuit of several groups is to build a framework to handle information from either PACS and HIS.[1] Most difficulties encountered in this enterprise arrive from connecting different systems. Even when data are found and their paths are setup, there is still a problem of how to assemble and display the information.

Since every information system is unique, in a sense that implementation is very specific for each institution, there is obviously no single solution for integrating them. On the contrary there are virtually endless possible solutions. The point is that the integration of information systems emphasizes the need for more generic and standardized methods. HL7 and DICOM are good examples of efforts in this field.[2,3]

CERN's "World Wide Web" (WWW or Web) suite of protocols is quickly emerging as a "de facto" standard for Internet services interfacing.[4] Most of Web's success is due to its intrinsic ability to present hypermedia elements (text and hypertext, images, video and sound) through multi-platform clients connected with a well established network environment (TCP/IP). Since many hospitals and other health-care services are already using TCP/IP, it seems logical that the Web is, at least, an alternative to be considered.

Many applications using Web clients as browsers for databases are emerging, and the development of special *gateways* for several types of Database Managing Systems (DBMS) is increasing. A subset of those gateways refer to routing SQL queries between WWW clients such as NCSA's Mosaic and a SQL Server.[5] Since SQL is also another widely used standard, including hospital applications, the usefulness of this union (WWW + SQL) looks very promising.

The other important feature of Web browsers is that they are available for almost all kinds of computers. This is a major issue when an universal interface is a need, which is the case of Medical Workstations capable of handling all kind of clinical data.

For the last four years our group has been working towards setting-up a networked environment for its truly integrated system: the *I³S*, which includes both HIS and PACS capabilities and is based on open standards.[6] When the WWW first came into sight, it seemed to match that project perfectly. Thus, the development of a prototype Web browser for the I³S was proposed and it is described in this paper.

METHODS

Background

As described earlier the I³S is currently based in an Ethernet network with both DECnet and TCP/IP protocols.[7] All hospital workstations, terminals, microcomputers and peripherals are networked as well as some dedicated imaging systems (at present MRI, SPECT and Cath Lab).

Patient identification, registration of performed procedures and their reports are being stored in a relational DBMS (Oracle-Rdb). The applications that provide data for the system are a full featured Report Generator and a Medical Procedure Registration System. The former is an old system developed in COBOL with embedded SQL and the latter a 4GL -based (MSE-Magic) application.

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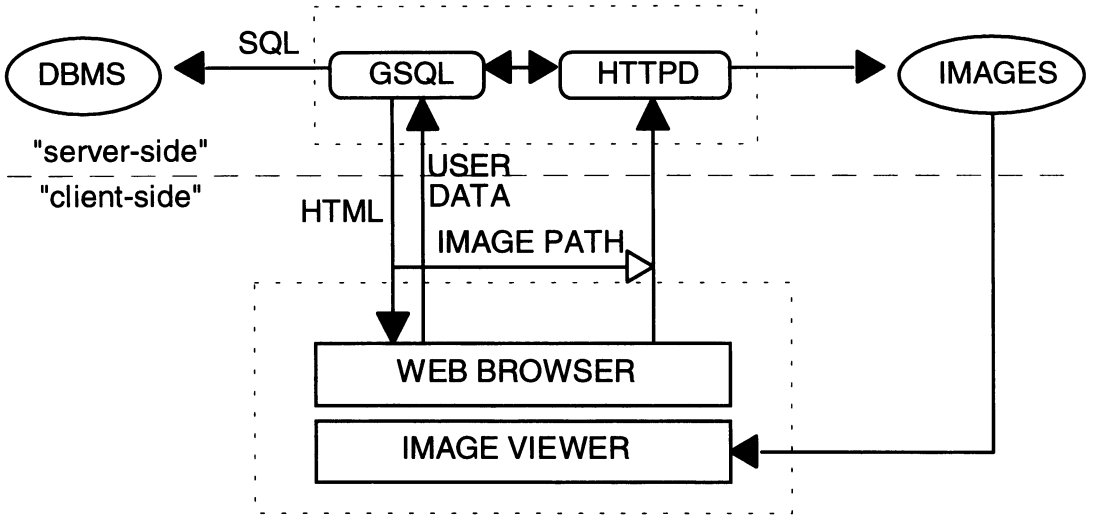

Figure 1. Schematic diagram of the Web for patient data retrieval (prototype).

File format converters, developed by our group, are available and enable handling and display of images over different platforms (operating systems and image processing/visualization software).

The Web services on the servers side were provided by CERN's *httpd* server, installed for both UNIX and VMS machines.[8]

The prototype

A sample dataset was created to test the Web browser. The original Oracle-Rdb database structure was duplicated for the Sybase DBMS and part of the data from the main database was transferred to it. The need for this process was twofold: first because, at that moment, GSQL (SQL gateway) had no driver for Rdb and second to protect the production database from any accidental fault.[9]

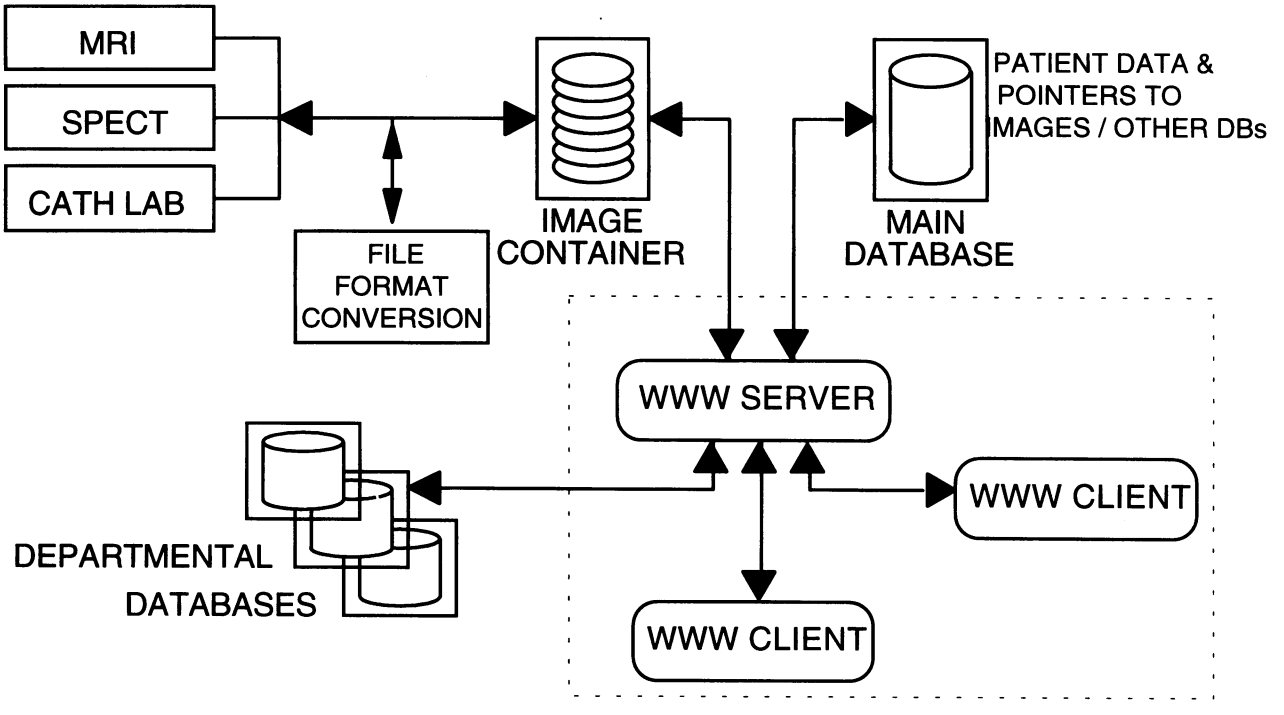

Figure 2. Diagram of the functional version of the Web (next step).

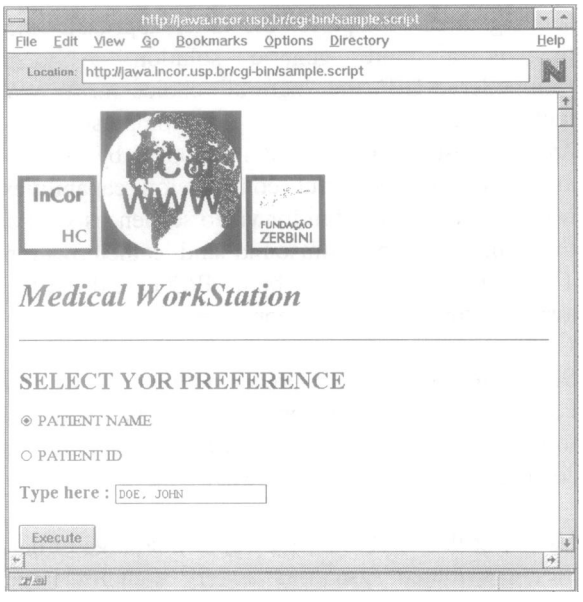

Figure 3. Home page of the prototype. The user is required to inform either the patient identification number or the name.

Some sample images were converted from their original (proprietary) formats to the GIF file format. A string containing the path for the images was then added to the test database. The path information is formatted as a hyperlink and the user can "click" on it to retrieve the image.

GSQL was modified to work with Sybase and re-compiled for our Solaris system. In order to build the queries and to format the output into HTML the appropriate changes (*script, proc* and *sqlmain*) were done. The "server-side" was then complete and the browsers could start retrieving data from it. Figure 1 shows a functional diagram of the prototype.

The Next Step

After validating the method with the prototype, the next phase will be to connect the Web with the actual patient database. A new GSQL set-up will be needed in order to enable communication with Oracle-Rdb's SQL-server.

For the next version, images will be made available by developing interfaces between the image acquisition systems and the patient database. This will allow the system to make the images available when they are processed. Figure 2 depicts the new scenario.

RESULTS

As the server became active, users could start to retrieve data from patients via their name or identification number (Fig. 3). Both text and images (where available) are displayed in response (Fig. 4). Either Mosaic and Netscape browsers are used in PCs and SUN-Workstations. Lynx was used as a browser for non-graphical terminals (Fig. 5).

The use of any of those browsers is very simple. All

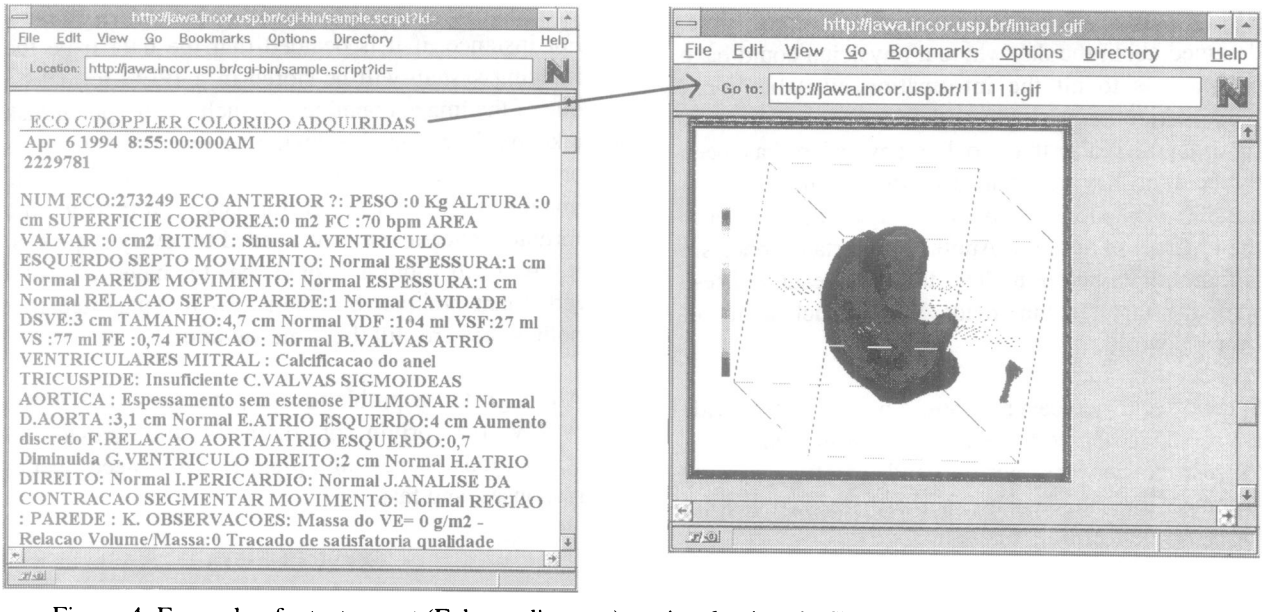

Figure 4. Example of a test report (Echocardiogram) retrieval using the Web prototype. Text description is presented (left). When the image hyperlink is selected, the corresponding image is displayed (right). Note that, because these are actual data, the text report is written in Portuguese.

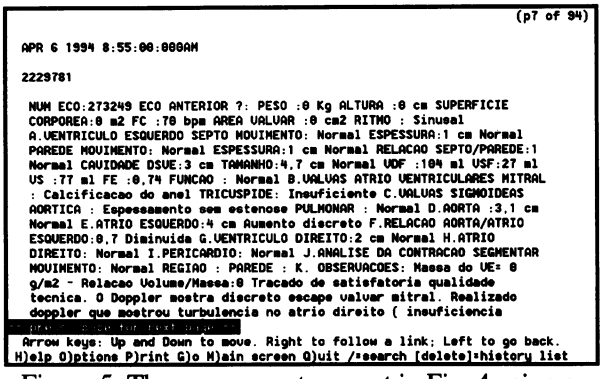

Figure 5. The same report present in Fig. 4 using a non-graphical browser (Lynx).

graphical browsers use the same metaphor of their underlying windowing system, so that the training required is minimal. Lynx has implemented a presentation and navigation system which has a "look-and-feel" that closely resembles its graphical equivalents, and although the commands are issued with the keyboard, its interface is also very friendly.

The response-time for the prototype is very good even on our 10 Mbps network. Each transaction typically takes a few seconds to be completed. It must be noted that, at this time, no video sequences have been used.

DISCUSSION

Most professionals working in projects related to concepts such as Medical Workstations, PACS, HIS, RIS, Medical Records, have, for a long time, dreamed about the day where a physician could have easy access to all the information available for a given patient in a single and friendly environment. In order to reach that goal, many effort has been directed at having standards that could make it possible. The more accepted the standard, the greater the chances of success. Another important aphorism is that simple solutions lead to better results. These were the features that made WWW such a hit all over the world.

Special security measures should be taken to provide a reasonable degree of security. Firewall technology, to restrict network access, and careful granting schemes for the database server, are two helpful measures concerning this issue.[10]

Another important issue is whether to have viewers for the different file formats at the clients (browsers) or to convert them on the "server-side" before sending them. We prefer the latter approach since this is a more generic solution. Although CompuServe GIF, the "natural" choice for WWW, includes some degree of lossless compression, we prefer to use JPEG since it is adopted by DICOM and has more powerful compression capabilities. MPEG can be a solution for video sequences such as those produced by ultrasound and catheterization. There are viewers for both JPEG and MPEG available for virtually any computer.

Since DICOM and HL7 already address many of the issues on communication, data query, and file format, the development of gateways for them should add extra flexibility for using WWW in hospitals.

Modeling the databases and physical storage of data in a distributed system is a very complex issue. Decisions on what should be kept or not, how to guarantee integrity throughout different machines, version synchronization, and reprocessing of raw data are among the tasks ahead of us.

Another question is how to automatically integrate image information to the patient database. A simple field with the name of the file and its location on the network is enough to make them available for retrieval. However, there is still a problem on how to append this piece of information without human interaction. In this project there will be a need for the technician that process the images to do this entry manually.

For instance, if it is decided that the data from the imaging system will be stored in a JPEG format on one of the image containers -- such as an optical disk jukebox, how can this image be re-processed by its original system? On the other hand, if we keep the images in their original formats, "on-the-fly" file format conversion will be needed for every request to it. A third option would be to have a costly redundant archive, but then how to guarantee that both copies are still the same version?

Although those problems are not new -- nor is the WWW the origin of them -- the growth of applications accessing images will need better responses, and fast.

CONCLUSION

The development of a prototype that uses Web services to retrieve patient data, proved that this is not only a feasible task but one very close to an

optimal solution. Since the Web is already being widely used for different kinds of applications, there are many options of software and hardware for it, and most of them are available at no cost.

The use of open solutions, instead of proprietary ones, highlights the advantages of developing and promoting public standards. In this case, the use of TCP/IP, SQL, WWW, as well as other open protocols, proved to be useful even in very specific and complex environments.

The main problems still to be solved refer to security, data modeling, implementation of new gateways for HIS and PACS standards (like DICOM and HL7). Managing distributed storage through an information network is another important matter, but this is by far a more general problem than one specific to using Web.

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